WHOI-75-47

Woods Hole Oceanographic Institution

STRUMMING TESTS ON TWO FAIRED CABLES

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TECHNICAL REPORT

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Approved for Distribution Earl E. Hays
Earl E. Hays, Chairman
Department of Ocean Engineering

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ABSTRACT

Measurements are presented of the transverse accelerations of faired and unfaired cables, suspended in water sixty feet deep with currents up to one knot while under 1000 lbs. tension. Four types of fairing were tested on 3/8" steel double armored wire rope, and one type was tested on 3/4" fibre line. The greatest reduction in strumming was obtained by use of many transverse fibres about eight times as long as the line diameter. There is large spread in the measurement results.

Introduction

Lines used to moor systems at sea are usually subjected to currents approximately normal to the line. This flow and the cylindrical shape of the line induces vortex shedding with resultant transverse accelerations of the line. These accelerations can be large enough to eliminate the possibility of measuring ambient acoustic noise or currents by instruments suspended from the line. A similar situation exists in cables used for towing equipment where the problem is more intense due to the higher speeds and the vibration can cause mechanical failure as well as create noise.

The vortex shedding can be reduced by changing the cross section of the wire to a stream line shape. This fairing of the cable has taken many forms. For short wires (several hundreds of feet) solid fairing in short sections is often used. For long wires (thousands of meters) usually flexible fairing must be used so that the wire may be reeled on and off winches in reasonable times.

We undertook a small study to measure the damping effects of several types of fairing on a 3/8" double armored wire cable, and also the effect of "hairy" fairing on a 3/4" synthetic fibre - Kevlar - cable. The tests were run in order to choose a wire for a vertical array of hydrophones measuring ambient noise in the ACODAC program. The assumption was made that the fairing giving the greatest reduction in a sixty foot length of cable would also be the most effective over much greater lengths. Currents of interest were a knot or less.

Experimental Method

The dock at the Woods Hole Oceanographic Institution has sixty feet of water at the outboard end, and due to the shape of the harbor, tidal currents are practically unidirectional, ranging from about zero to one and one half knots. The current runs against the dock from the west, and as the dock's structure in the water is a set of long narrow pilings the flow up to the dock is essentially unimpeded and can be used as a large flume.

This flow is not as uniform as one would have in a flume, and the magnitude and time of the currents is tidal controlled. However it makes a convenient place to see characteristic behavior if not detailed behavior.

Figure 1 illustrates the cable arrangement during the tests. A 2000 lb. weight was supported by the two cables being tested. The two cables were supported at the top by an A-frame with the force distributed equally on the cables. The cables were about five feet apart with the current perpendicular to the plane.

Two accelerometers (5 g full scale) were mounted in a crossed axis configuration at the midpoints of each of the cables. The mountings were made as light as practical to reduce any nodal effects. The small signal leads came off on the down stream side and were faired to reduce effects on the test cables.

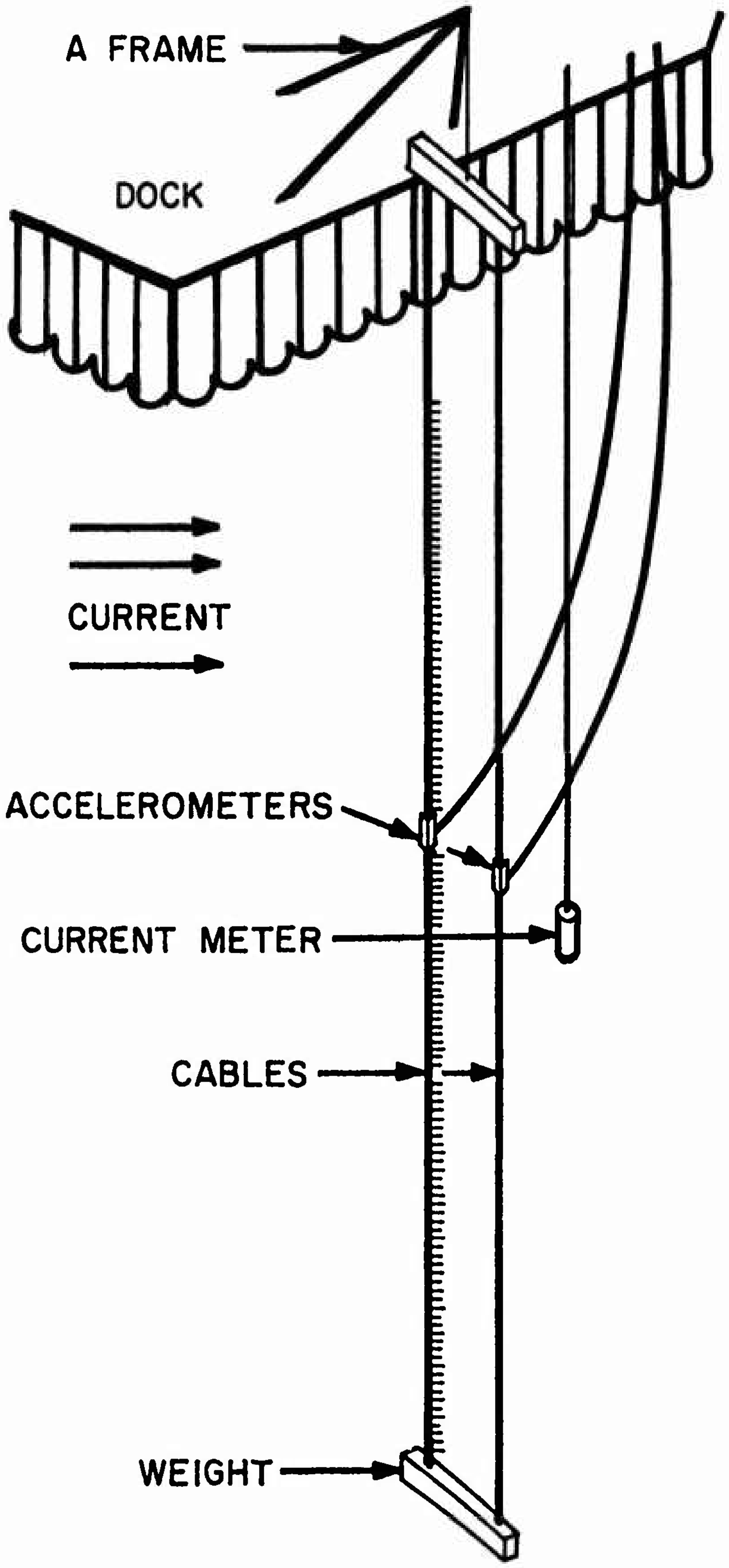

Figure 1 Experimental Set-Up

A Savonius current meter was placed downstream from the test site near mid-depth to supply current information.

Faired and unfaired cables of the same type were used during each test. The outputs from the four transverse accelerometers (two per cable) were displayed in a four channel oscilloscope, and the peak-to-peak levels were measured for each accelerometer during the current cycle, at the same time current measurements were made. The peak-to-peak measurements for each pair of accelerometers were combined to give the vector resultant. From this, plots of the ratio of the peak magnitudes for faired and unfaired cables versus current were made. In the plots this ratio is

$$R = \sqrt{\frac{(\text{Ch } 1)^2 + (\text{Ch } 2)^2 \text{ unfaired}}{(\text{Ch } 3)^2 + (\text{Ch } 4)^2 \text{ faired}}}$$

(Ch 1) etc. is the peak-to-peak millivolt output of the accelerometers during the test.

This "simultaneous" measure of the acceleration for faired and unfaired cables helped to reduce the effects of variability in water flow but was not completely successful.

The acceleration frequencies observed on the oscilloscope corresponded to the expected Strouhal frequency. Two differences existed between the response of the Kevlar and the steel armored cable. The wave form for the Kevlar contained many more harmonics than for the armored cable implying a lower Q, broad band response. Also for the armored cable the length and tension were such that a half wave length for cable resonance was about the cable length. The resonance frequency would show up as a modulation on the Strouhal frequency on the oscilloscope display.

Cables and Fairings

Two types of cable were used during the test. One was a double armored wire 3/8" in diameter with a central core of seven conducting wires. This weighed 0.2 lbs. per foot in water and had a breaking strength of 13,000 lbs. The other cable (Wall Rope Uniline 3/4") had strength members made of Kevlar. The central core consisted of six triad conductors surrounded by a ring of Kevlar bundles covered by a nylon braid jacket. This cable weighed 0.07 lbs. per foot in water and had a breaking strength of about 13,000 pounds.

Four types of fairing were tested on the steel cable and one type on the synthetic cable. These are illustrated in Figure 2. Some of the fairings were changed by shortening the length or changing the spacing to obtain some idea of how the fairing might work after being used on a winch many times and what fairing density was necessary.

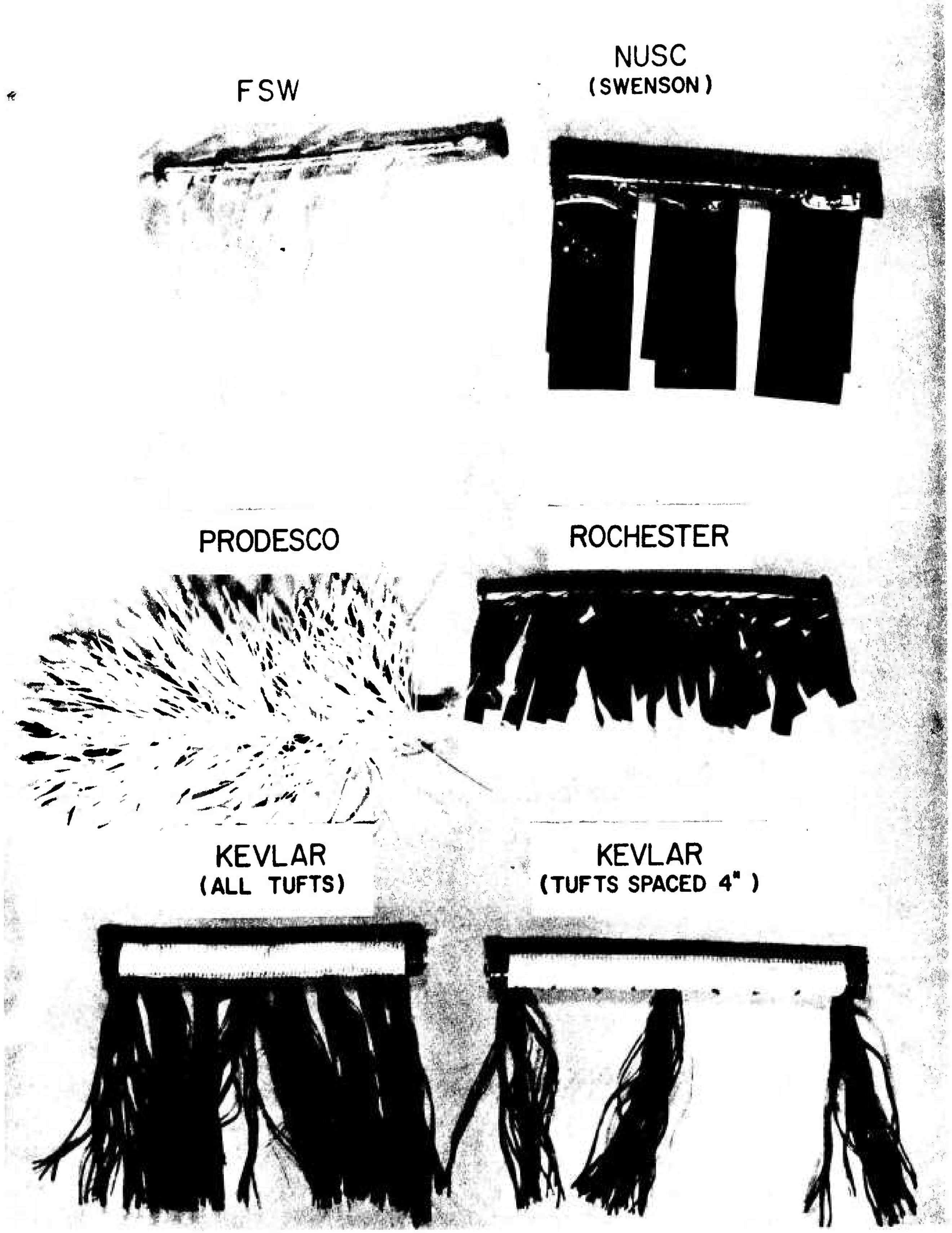

Figure 2 Fairings Used in Test

Fairings Used

FSW Fairing. This (Fringe-Spiral-Wrap) consisted of a strip of six mil. polyurethane eight inches wide, cut transversely to within one and one-half inches of one edge in strips one inch wide. This was wound and glued in a spiral wrap around the cable. The fairing length was reduced to four inches after testing the original (≈six inches) and retested.

NUSC (Swenson). This was two inch wide polyurethane strips folded over and bonded to a polyurethane jacket which had been extruded on to the cable. The flags had a length of about five inches and were separated by one-half inch.

PRODESCO. This is a patented product made by taking 10-12 inch lengths of PVC filaments laid parallel and bound together by a central one inch wide tape of fibres woven lengthwise down the center of the assembly. The resulting fringe tape is wound in a spiral around the cable and cemented in place. The fibre length is about five inches.

Rochester. One-half inch wide ribbons of polyurethane nine inches long were threaded under one strand of the outer layer of the steel cable. The ribbons were packed closely along the length.

Kevlar. Bundles of PVC fibres were imbedded in the nylon jacket during manufacture. The resulting fairing was about five and one-half inches long, spaced in bunches one-half inch apart along one side of the cable. The Kevlar in Figure 2 is that used for a mooring after the tests and not that used for the test. (Spacing of tufts one inch vice one-half inch).

Data Presentation and Discussion

The acceleration ratios are plotted as a function of current in Figures 3 through 5 along with curves which result from a quadratic best fit to the data for each fairing type. One thing that is apparent in the data presented is the large spread in the measurements. The peak-to-peak levels were read from an oscilloscope and were visual averages over several minutes. The error in this measurement is estimated at about 20%, that is, different observers would pick numbers within 20% of each other for a given period. Contributing more to the wide spread in data was the instability in the flow. In observation of the surface, eddies were seen to sweep towards the dock. It is also apparent that in some instances the data did not span enough of the range of current values, which is probably the explanation for the negative slopes for two of the curves.

Interpretation of the data requires the assumption of similar flow passing by the two wires and the current meter. This is true only in a gross way. This means the data is only a first approximation to engineering data, but it appears good enough to do some classification of the effectiveness of the different fairing types.

All of the fairings used reduced strumming, some more effectively than others. Figure 3 shows the data for the four fairing types used on the 3/8" armored cable. The PRODESCO fairing has somewhat higher ratios than the other fairings with the Rochester being a reasonable second in effectiveness. In this figure the four inch FSW was plotted as it had somewhat better performance than the six inch FSW as shown in Figure 4.

The Uniline data is plotted in Figure 5. This data shows that tufts spaces at one inch are about effective as tufts spaced at one-half inch, but two inch spacing shows a decrease in effectiveness. On this basis cable was ordered using the one inch spacing.

When all the acceleration versus velocity data is plotted for unfaired Kevlar and the armored cable Figure 6 , it is seen that the accelerations are much the same.

Conclusions

On the basis of the tests a Kevlar 3/4" cable was ordered with tufts spaces every one inch. A deployment using this cable showed no evidence of strumming in an area where a previous unfaired cable had much strumming. The tests showed that one inch spacing was about as effective as one-half inch spacing and the one inch choice reduced the price of the cable.

For the armored cable the "hairy" fairing has a small advantage over the strip type. It is possible to have too much strip fairing on the cable as is seen by the low effectiveness of the FSW six inch fairing.

Other strumming studies are now underway elsewhere to obtain more precise data about cable strumming.

There is a report on the drag characteristics of the Kevlar faired cable in the form of an M.I.T.'s master thesis. (The Hydrodynamic Behavior of A Streamer Type Faired Cable in Various Flows", by Steven H.Cohen. Ocean Engineering Department M.I.T., January 1975.) This says that multiple rotations (wrapping the fibres around the cable) will increase drag, and the drag of the faired cable will be higher than that of the unfaired cable at low currents (Reynolds number). Other features are discussed for velocities not normally seen in the deep ocean.

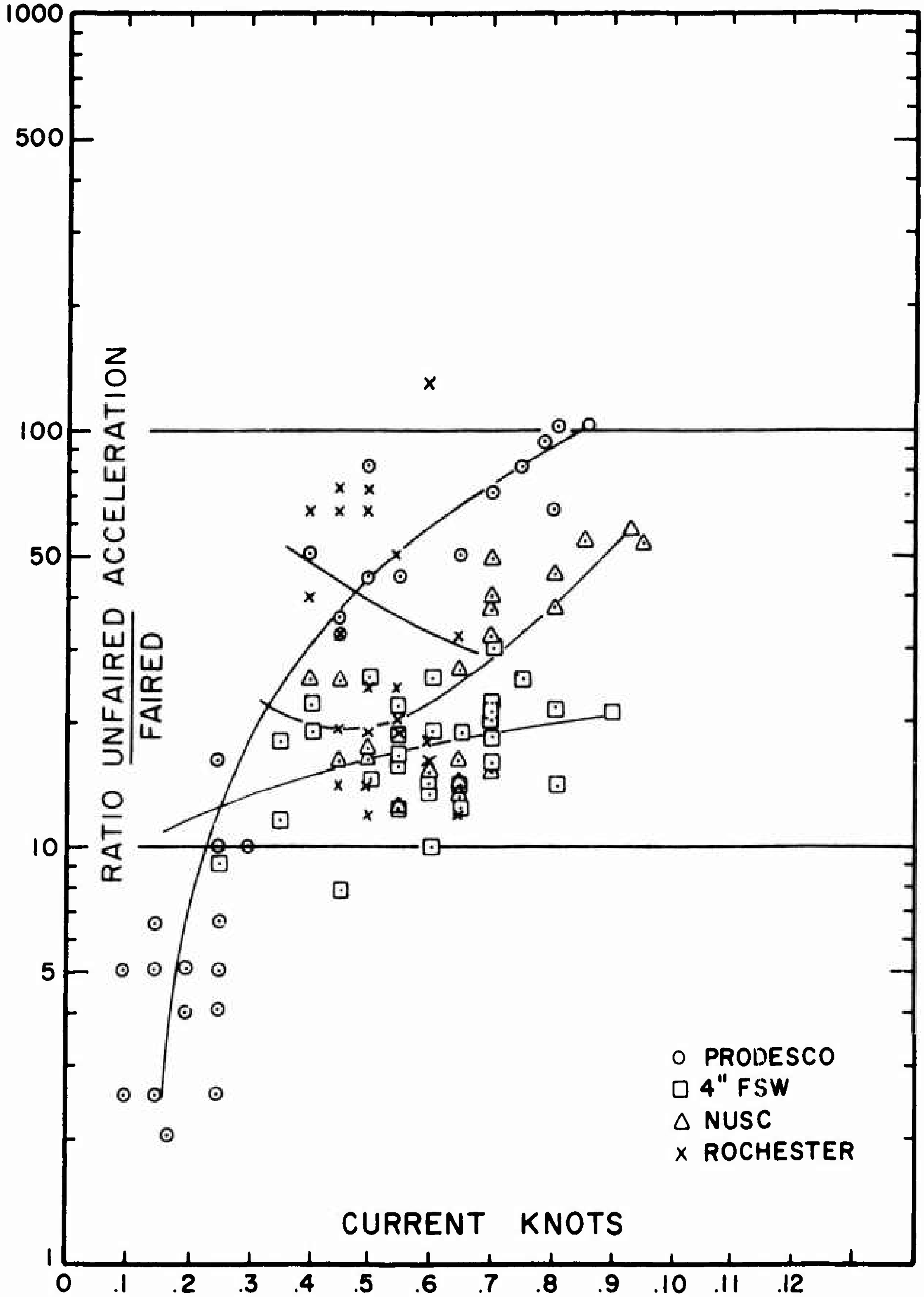

Figure 3 Acceleration Ratios for Four Faired Wire Ropes

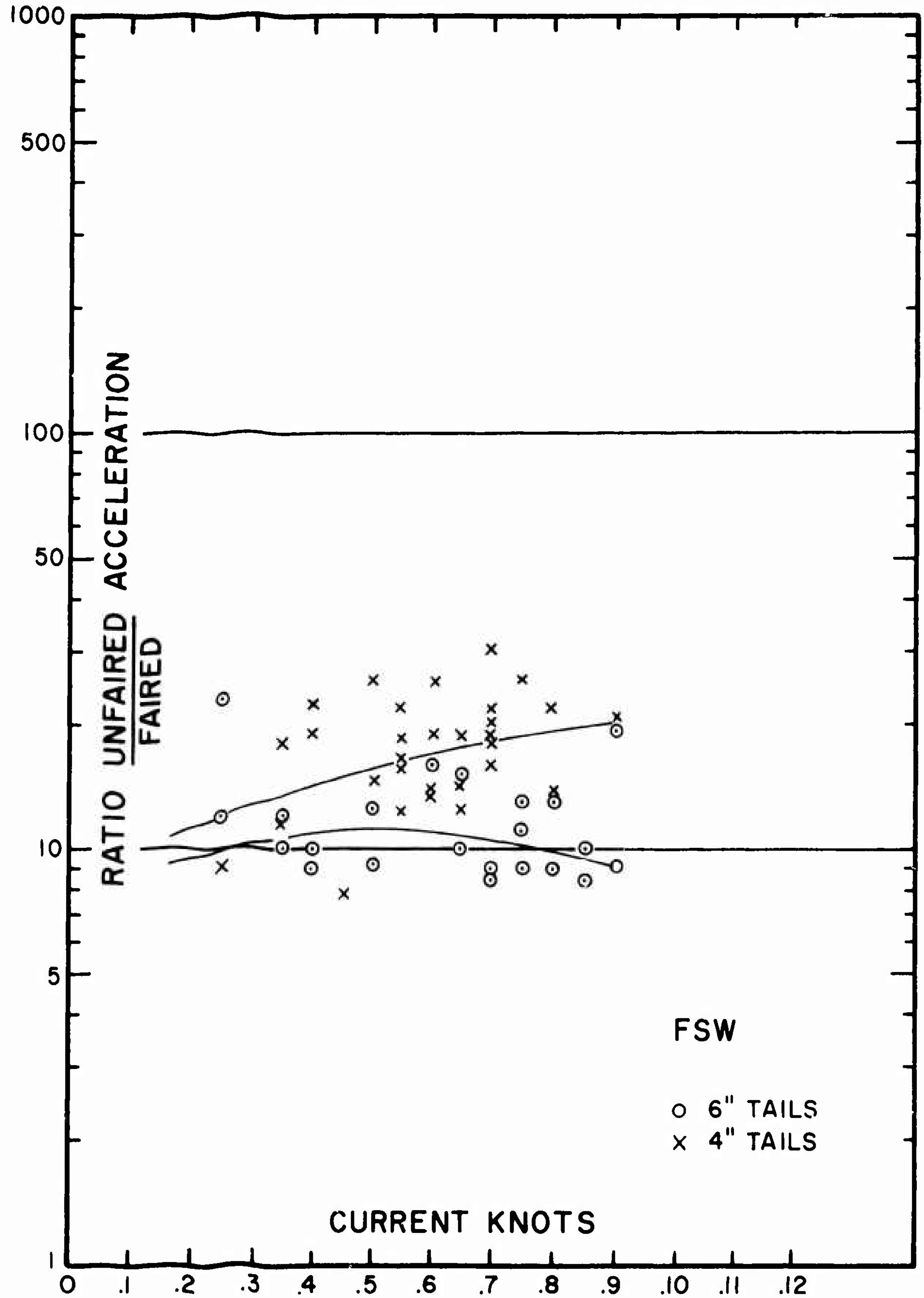

Figure 4 Comparison of Accelerations for 4" and 6" FSW Fairings

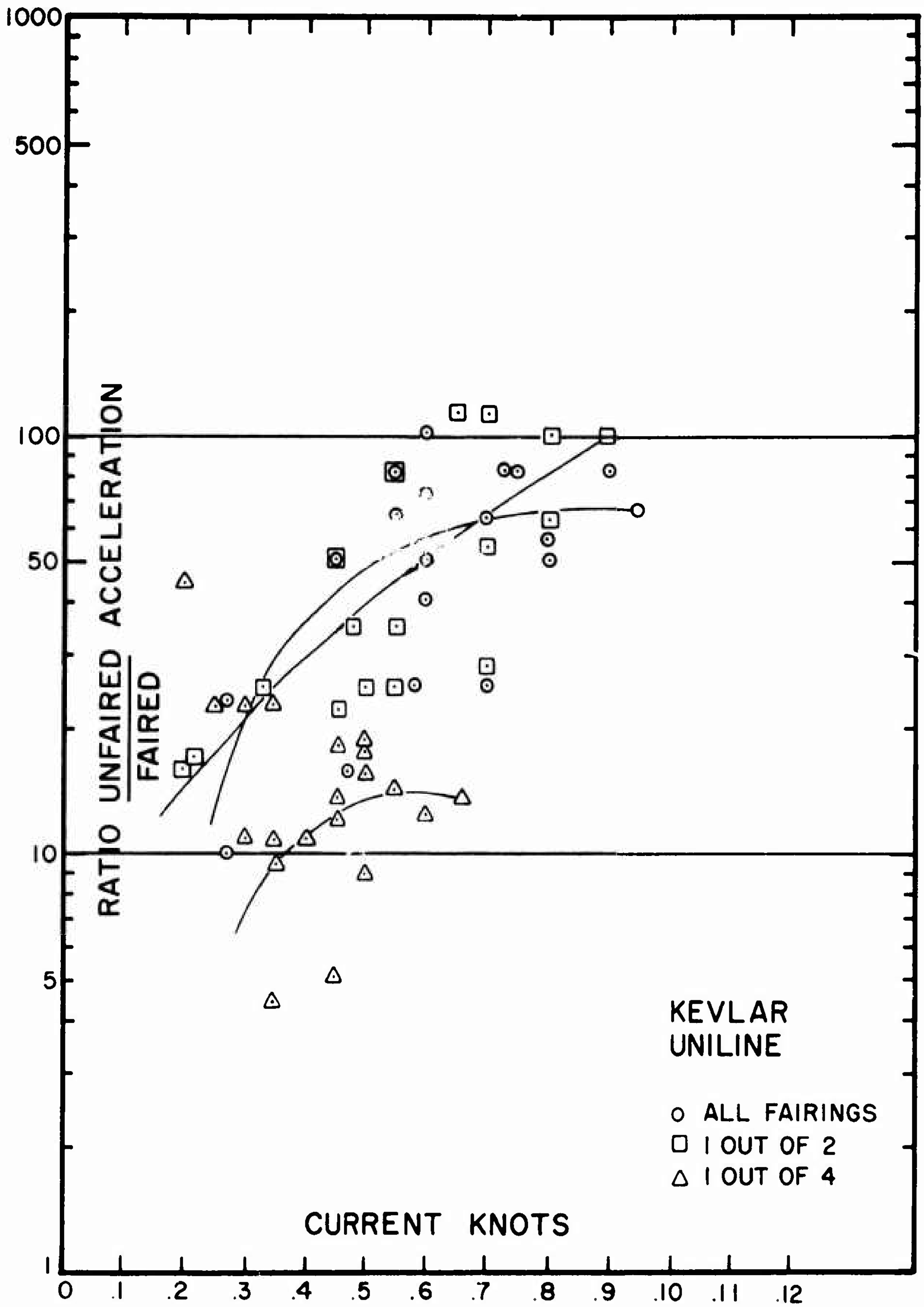

Figure 5 Effectiveness of Fairing Density on Kevlar Line

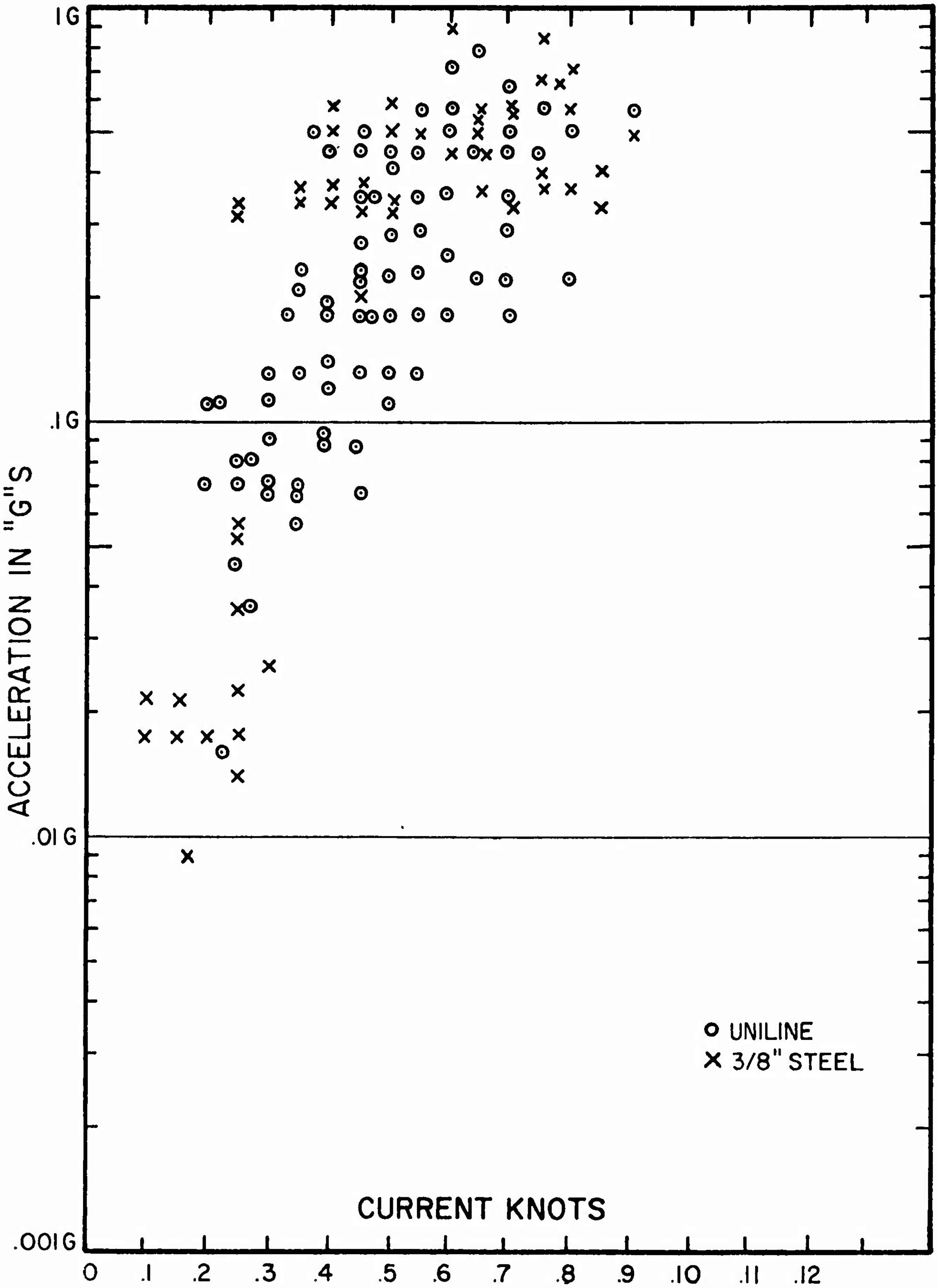

Figure 6 Accelerations for 3/8" Steel and Kevlar

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2. Fairing

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